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Electron Microscopy Characterization of Adhesion Layer Influence on Ultra-thin Gold Films

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Au, Ag and Cu are used in a wide range of applications and research areas, e.g. semiconductors, plasmonics, metamaterials and 2D materials. However they are strongly affected by poor mechanical adhesion to the substrate, leading to thin-film peeling and time-dependent device performances deterioration. To enhance their adhesion, thin *adhesion layers* such as Ti and Cr are introduced. There is little knowledge on the effect of an adhesion layer on the nanostructure of functional metal thin-film overlayers. There is also a lack of information regarding the final structure of the Au film when different adhesion layers are used. Comprehension of these changes might have an important impact on fabrication of nanodevices with superior electrical performances, since thin-film nanostructure is directly connected to electrical conductivity.

In this work, using complementary electron microscopy characterization techniques, we investigated how Cr and Ti adhesion layers influence the nanostructure of ultra-thin Au over-layers. TEM cross section and EDX analysis showed the different morphology of SiO_2/Ti/Au and SiO_2/Cr/Au multilayers, revealing high Cr diffusion into Au as opposed to the Ti case. Using Transmission Kikuchi Diffraction (TKD) [1] we detected a change of grain size and orientation of the Au overlayer compared to pure Au (Fig. 1A) for both adhesion layers. Using STEM-EELS we observed that both adhesion layers are oxidized (Fig. 1B). Integration of these results with XPS depth profile showed that the partial oxidation happens during film deposition for both adhesion layers. Micro 4-point probe measurements presented electrical conductivity increase for Ti/Au and deterioration for Cr/Au stacks compared to pure Au, attributed to film parallel resistor behavior [2] and Cr/Au alloy formation, respectively.

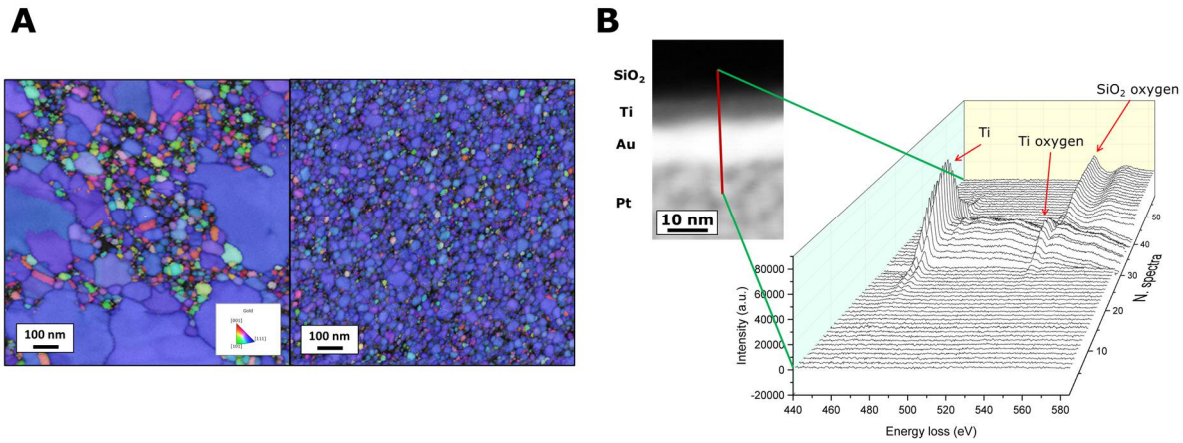

Figure 1: (A) TKD IPFZ map of 20 nm Au (left) and 2nm Cr/20nm Au (right); (B) STEM-EELS linear scan of 2nm Ti/2nm Au sample.

[1] R. R. Keller, R. H. Geis, *Journal of Microscopy* **245 (3)**, 245-251 (2012).
[2] Y. Y. Chen, J. Y. Juang, *Meas. Sci. Technol.* **27 (7)**, 74006 (2016).